Chapter 5.1

Total organic carbon in Maryland Coastal Bays sediments: Status of a regulator of chemical and biological processes

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Abstract

Total organic carbon in sediments regulates the behavior of other chemical species such as metals. The indicator for total organic carbon was calculated as the percentage above that indicated by natural clay content in the sediment (excess organic carbon). Excess organic carbon values ranged from –0.73% to 5.12% in Coastal Bays sediments. The St. Martin River, Herring Creek, and Newport Creek were found to have high levels of excess organic carbon, a factor that may be affecting benthic communities. The open water portions of the Coastal Bays did not contain high levels of excess organic carbon.

Introduction

Total organic carbon has a major influence on both the chemical and biological processes that take place in sediments. The amount of organic carbon has a direct role in determining the redox potential in sediment, thus regulating the behavior of other chemical species such as metals.

Sources of organic carbon include organic matter from overland runoff and shoreline erosion (mostly marshes), and primary productivity within the bays, all of which eventually settle to the bay bottom and are incorporated into the sediment. Since organic matter is a primary source of food for benthic organisms, it is important in maintaining a viable ecosystem. However, too much organic matter can lead to the depletion of oxygen in the sediment and overlying water, which can have a deleterious effect on the benthic and fish communities.

Total organic carbon (TOC) content in sediments has been used as an indicator of pollution and eutrophication rate (Folger 1972; EPA 2002). Excess carbon may be attributed to either excessive plant debris (such peat from eroding marshes) or anthropogenic loading. High organic carbon in the northern bays is considered a sign of frequent algae blooms in the overlying water column, the blooms being a result of increased nutrient (nitrogen and phosphorus) loadings into the system. TOC content is proportional to organic matter, which has an affinity for trace metals and organic contaminants.

Data sets

CZM/MGS Sediment mapping report (Wells and Conkwright 1999)- providing basis for predicting TOC in sediments
EPA National Coastal Assessment Program (NCA): sediments collected in 2000 for MCBP

Management Objective: Reduce sediment inputs (MCBP CCMP 1999).

Indicator: percent Excess organic carbon (Ex-OC) $\leq$ 1%

EPA (2002) recommended the following assessment categories for TOC in sediments:
Low impact: $\leq$ 1%
Intermediate impact: 1 to 3%
High impact: >3%

The threshold values were based on EMAP data that indicated TOC values between 1% and 3% were associated with impaired benthic communities. However, these thresholds are still under evaluation.

Analyses

TOTAL ORGANIC CARBON IN MARYLAND COASTAL BAY SEDIMENTS

Wells and Conkwright (1999) found that clay content in Coastal Bays sediments is a very good indicator of minimum values for carbon content (Figure 5.1.1). For example, sediment consisting of 25% clay-size particles would be expected to contain at least 1.25% total carbon. They also determined that organic carbon accounts for 90% of total carbon in Coastal Bays sediments. Therefore, clay content (% clay-sized fraction) can be used to predict organic carbon content (Equation 1).

$$C_{organic} = 0.0448 * \%Clay - 0.079 \qquad \textbf{(Equation 1)}$$

Wells and Conkwright (1999) used this relationship to assess excessive carbon above "background" in the sediments of the Coastal Bays. The excess carbon is interpreted as increased organic input due to anthropogenic activities. They found that the sediments collected in the upstream areas of Roy Creek, Greys Creek, Trappe Creek, and St. Martin River were excessively enriched in total carbon

Excess organic carbon is calculated for the NCA/MCBP 2000 data using Equation 1. Because clay content was not measured, moisture (%water) and siltclay (mud%) were used to calculate clay content (Equation 2). This equation was derived from regression analyses of the textural parameters of 963 sediment samples collected by Wells and Conkwright (1999).

$$\%Clay = 0.309\ (\%Mud) + 0.0557\ (\%Water) \quad (R^2 = 0.949) \qquad \textbf{(Equation 2)}$$

Excess organic carbon values ranged from –0.73% to 5.12%. Values between –1 and 1% are within the error of the prediction model, thus these were considered to be within normal levels. Figure 5.1.2 shows the distribution of excess organic carbon (Ex-OC) in the Coastal Bays based on sediment data collected in 2000. Excess organic carbon assessment categories are similar to those suggested by EPA (2002):

Low : ≤ 1%
Intermediate 1 to 3%
High: >3%

Summary

St. Martin River, Herring Creek and Newport Creek have excessively organic rich sediments, which may have an impact on benthic communities. Sediments in the open water areas of the bays are not enriched in organic carbon. Except for one station in Isle of Wight Bay, Ex-OC values fall with those reported by Wells and Conkwright (1999).

References

Folger, D.W. 1972. Characteristics of estuarine sediments of the United States: U.S. Geological Survey Prof. Paper 742, 94 pp.

U.S. Environmental Protection Agency (EPA). 2002. Mid-Atlantic Integrated Assessment (MAIA) Estuaries 1997-98: Summary Report, EPA/620/R-02/003,115 pp.

Wells, D.V, and R. Conkwright. 1999, The Maryland Coastal Bays Sediment Mapping Project - Physical and chemical characteristics of the shallow sediments: Synthesis Report and Atlas, Md. Dept. of Natural Resources, Maryland Geological Survey, Coastal & Estuarine Geology Program File Report 99-5, ***HTML***-format on CD-ROM.

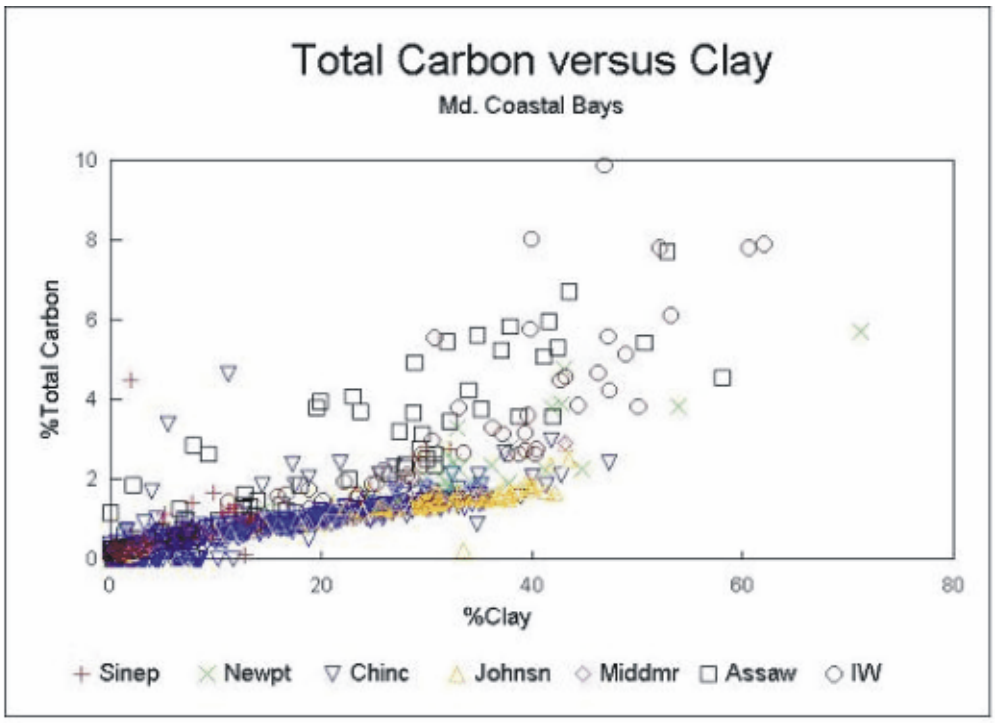

Figure 5.1.1: Plot of total carbon versus clay content for 963 surficial sediment samples collected in the coastal bays between 1991 and 1995 (Wells and Conkwright, 1999). Sediment samples are grouped by sub-basin. Sinep=Sinepuxent Bay; Newpt=Newport Bay; Chinc=Chincoteague Bay; Johnsn=Johnson Bay (Chincoteague); Middmr=Middlemoor Ditch (Chincoteague); Assaw=Assawoman Bay; IW=Isle of Wight Bay.

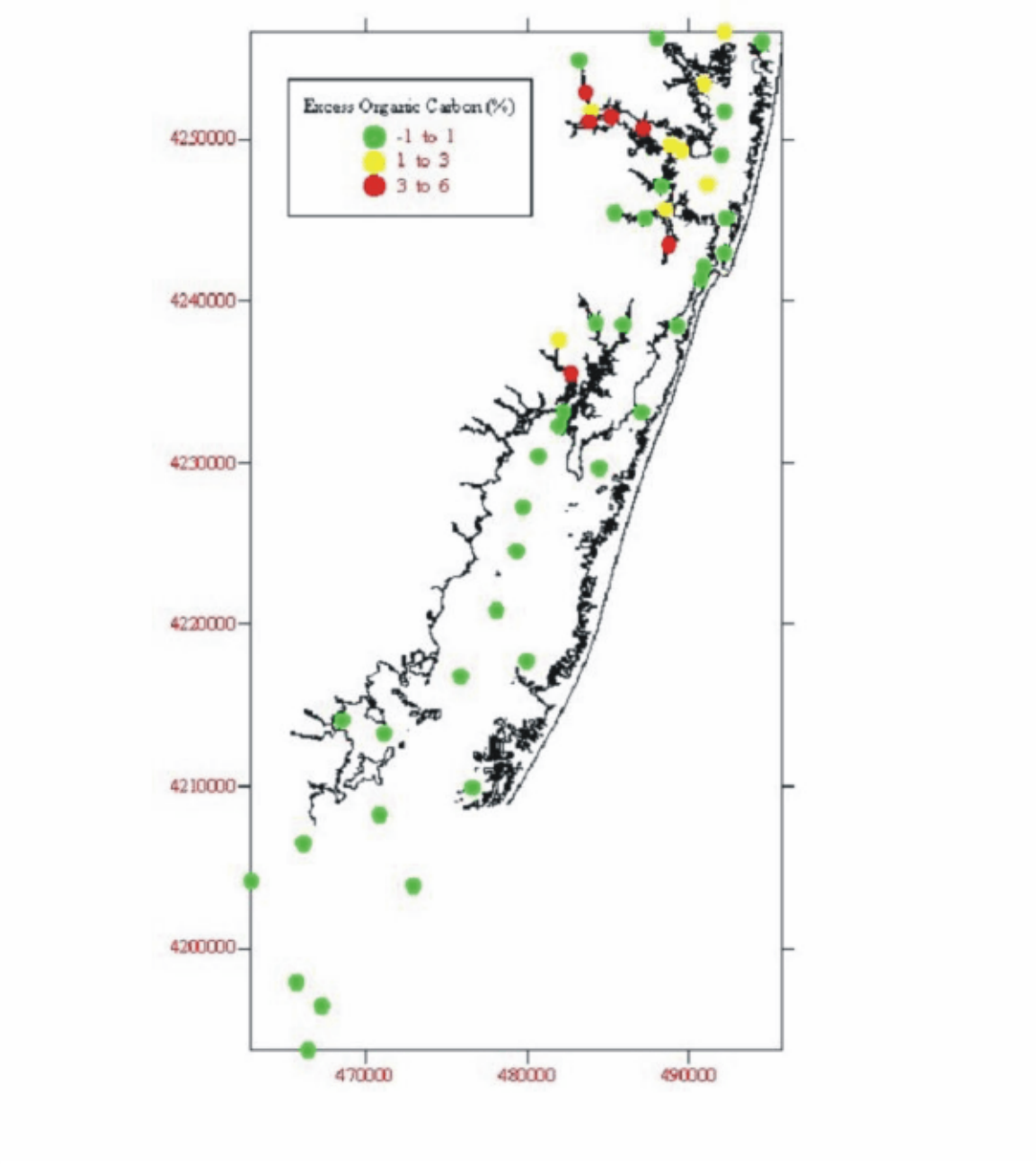

Figure 5.1.2: Map showing levels of excess organic carbon in sediments collected in 2000.